Application of satellite-based rainfall data to runoff analysis

6th International GPM Planning Workshop

Hironori Inomata[1)], Kazuhiko Fukami[1)]
1) Hydrologic Engineering Team, International Centre for Water Hazard and Risk Management (ICHARM)

Introduction

Establishment of River Planning for Water Utilization or Flood Prevention

↓

Understand Hydrological Characteristics of an interested basin

↓

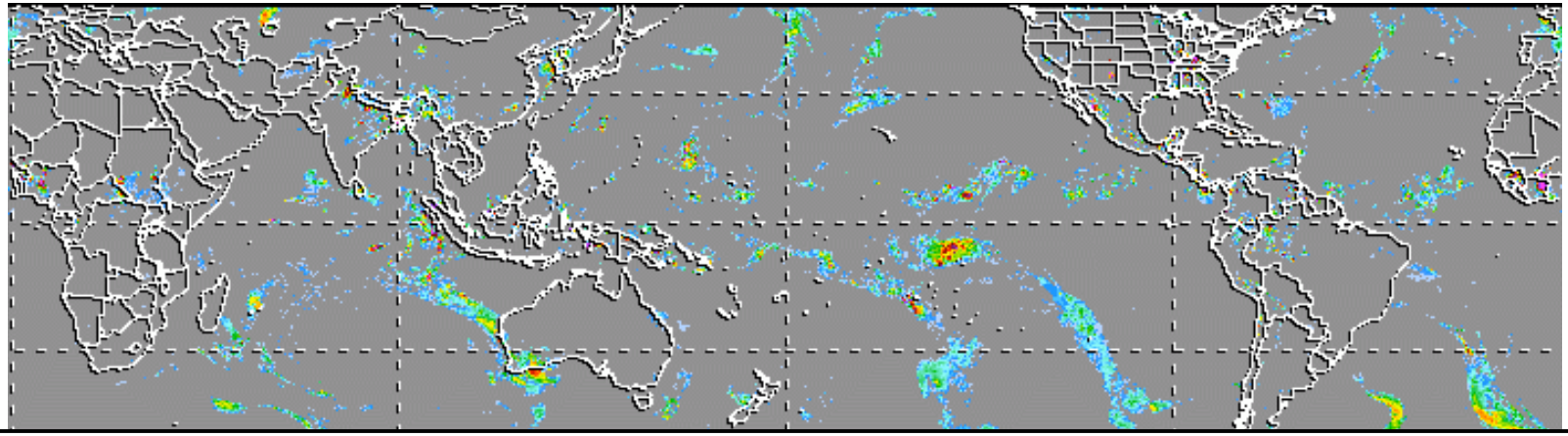
Need of Hydrological Data (Rainfall, Discharge…)

Many Areas in Developing Countries

There are so many areas in which hydrological data is poor in developing countries. (Ungaged Basins)

This leads to the difficulty to understand the hydrological characteristics of a basin.

Introduction



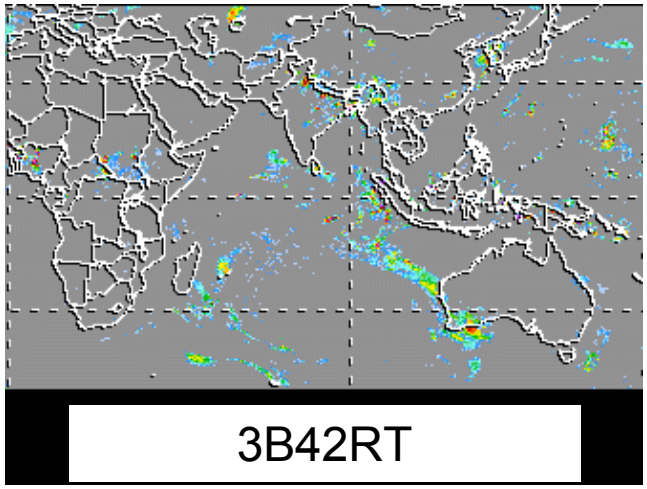
If the accuracy of satellite-based rainfall data is confirmed, it can become a very powerful tool for water assessment in ungaged basins.

↓

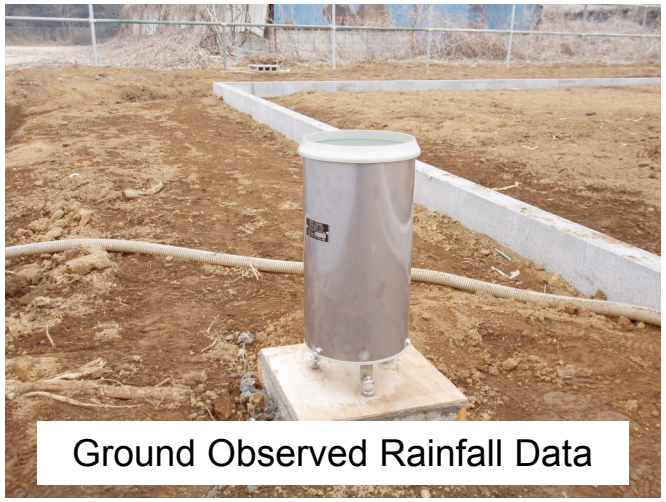
The applicability of global rainfall distribution data for hydrological use is studied.

In this study, 3B42RT by NASA is applied for experiment.

Method

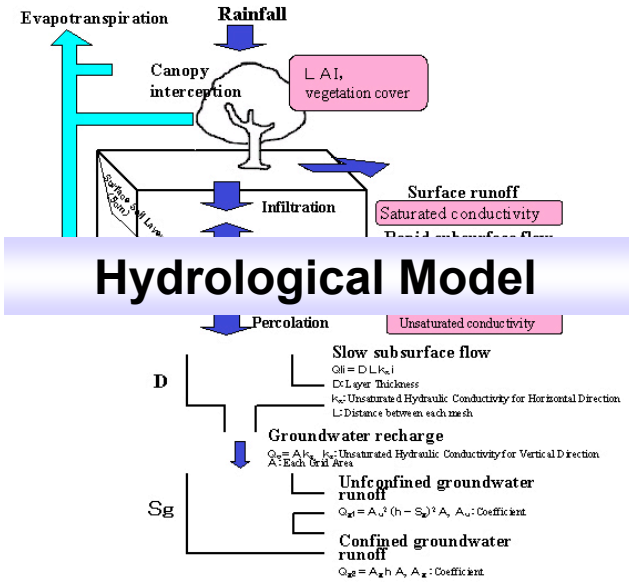


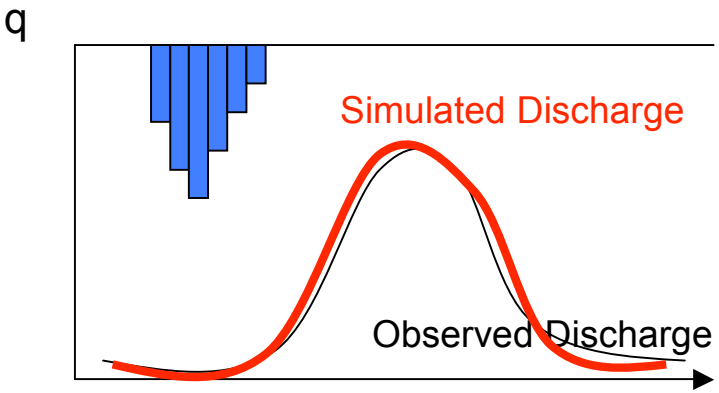
Compare



Input to Hydrological Model

Examine the accuracy by rainfall



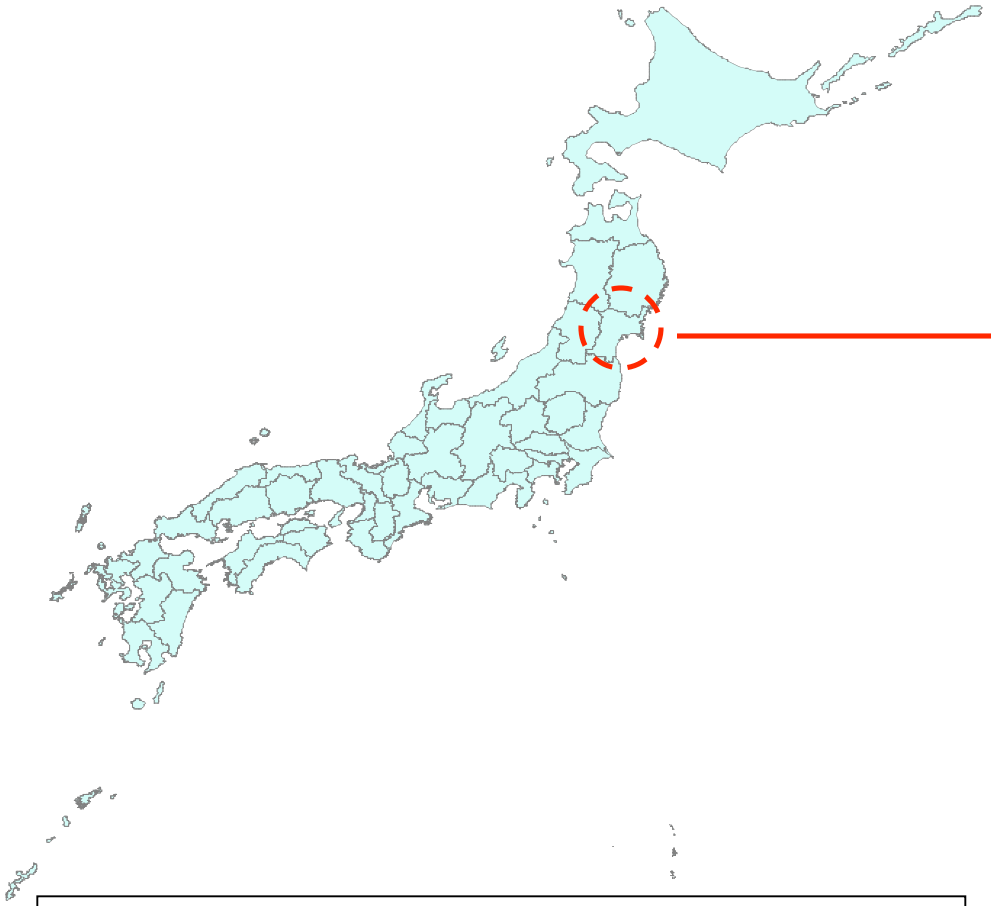


Examine the applicability by discharge

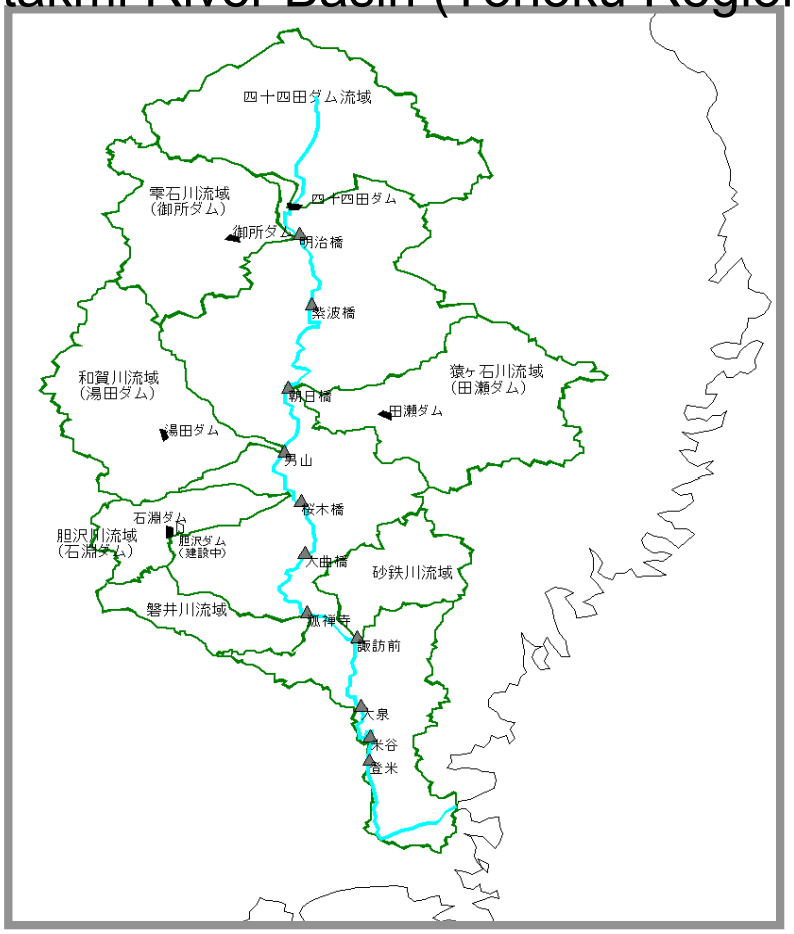
Experimental Basins

1. Kitakami River Basin (In Japan, 8,246 km^2)
   Well Gaged Basin
2. Onga River Basin (In Japan, 1,026 km^2) Well Gaged Basin
3. Pursat River Basin (In Cambodia, 6,013 km^2)
   Poor Gaged Basin

Kitakami River Basin



Kitakmi River Basin (Tohoku Region)



Experimental Rainfall Event

- Typoon 6th (7th to 9th of July 2002)
- Accumulative Rainfall (Areal Average: Kozenzi Upstream): 166 mm

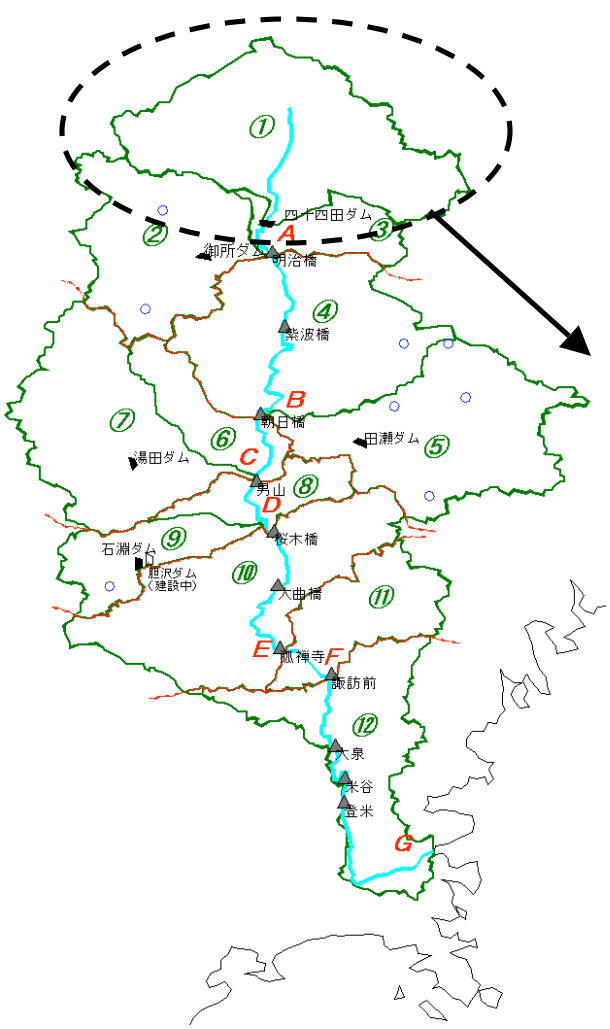
Area: 8,246 km^2

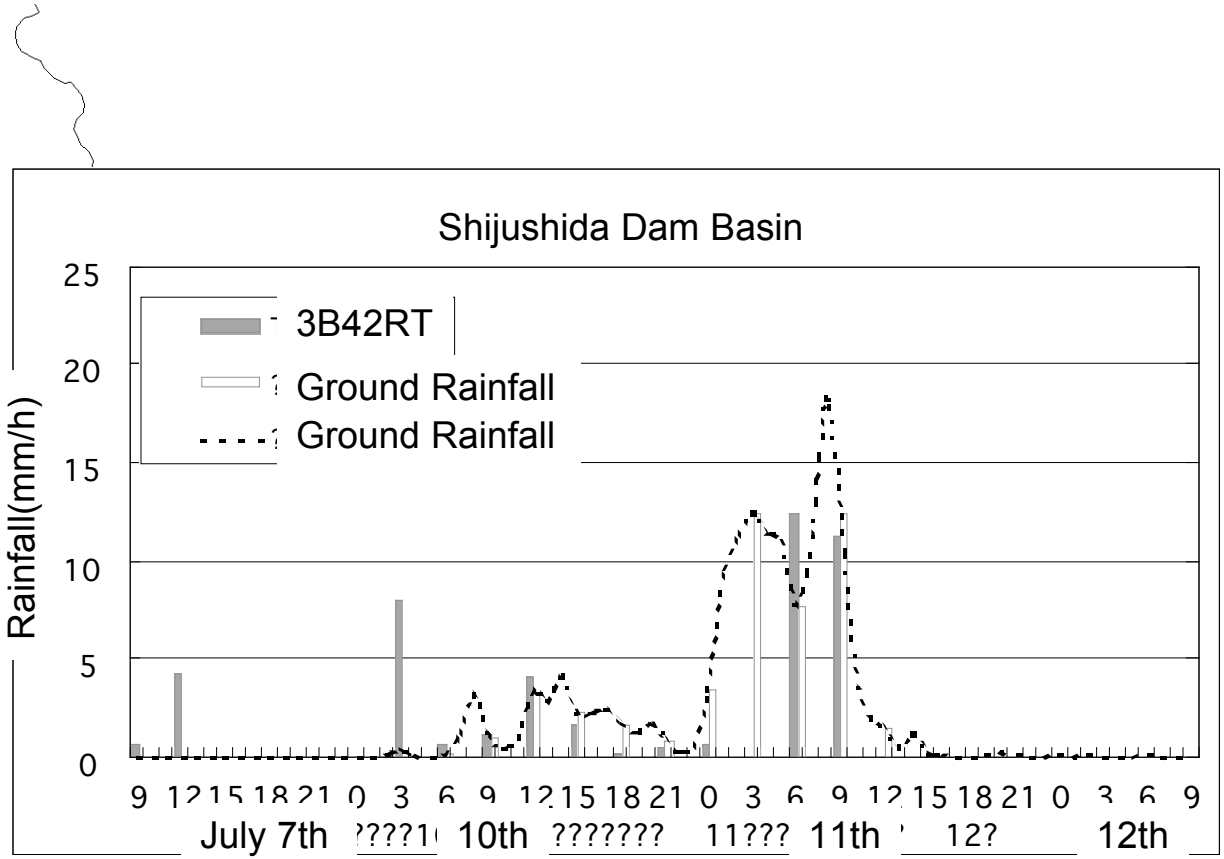
Rainfall Stations: 154 stations

(53.5 km^2/station)

Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

Comparison by Rainfall

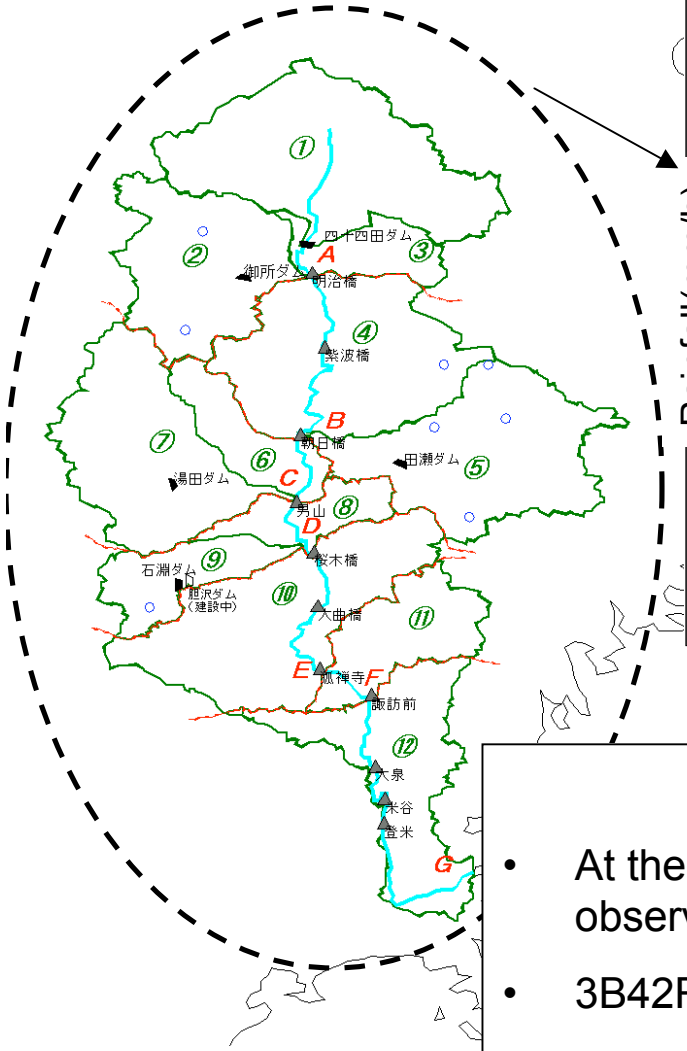


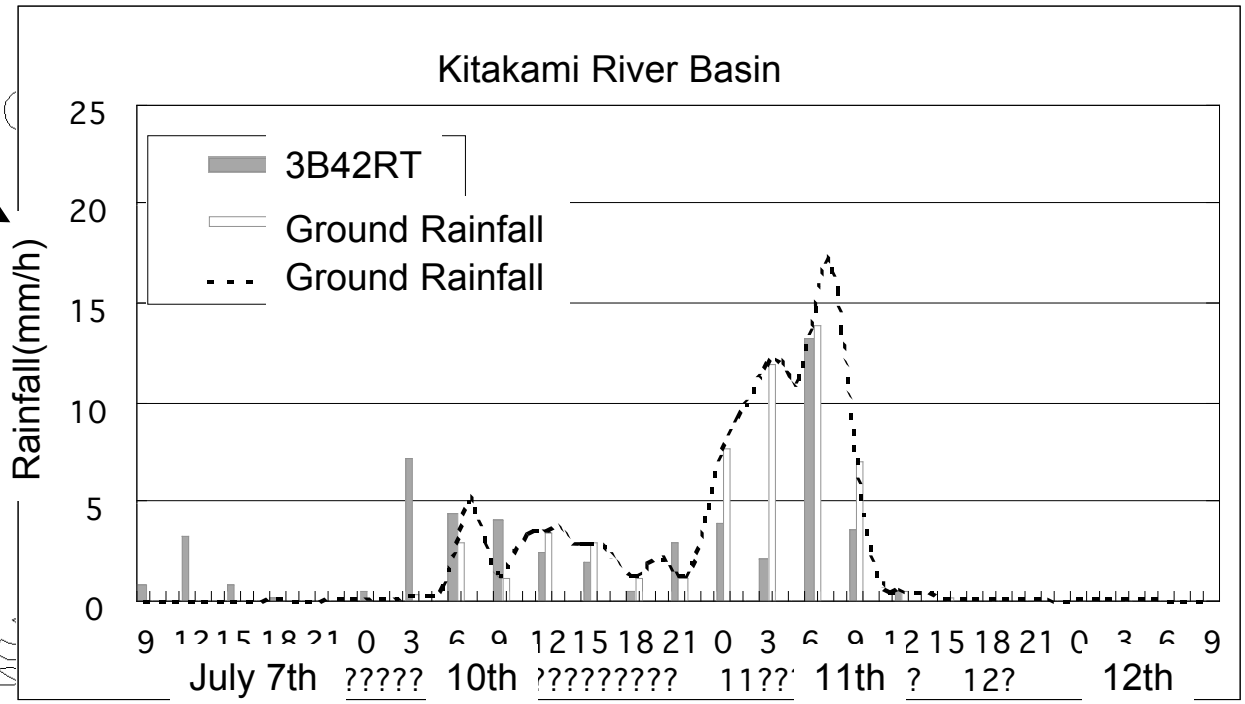


Sub basin A : Shijushida Dam Basin (1,196 km^2)

Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

Comparison by Rainfall





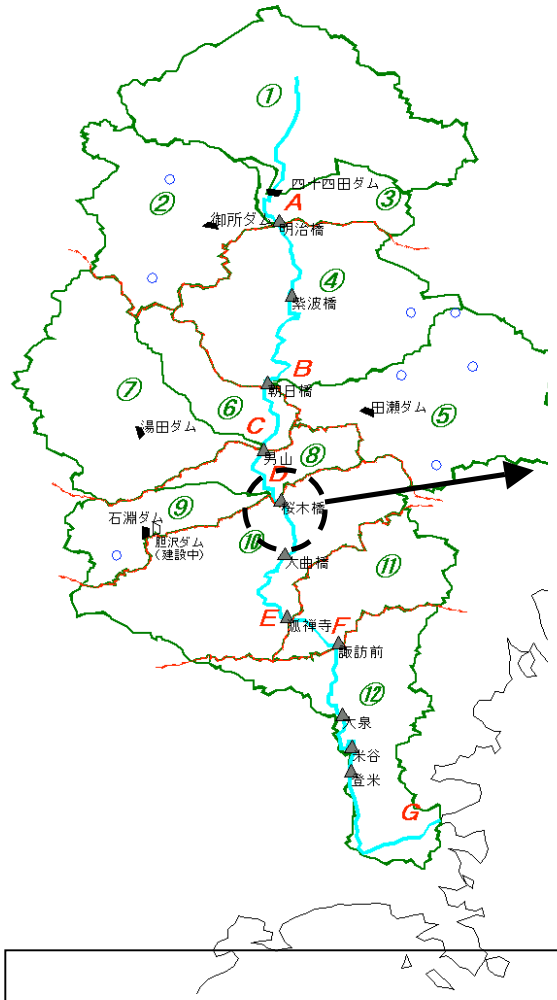
Kitakami River Basin (8,246 km^2)

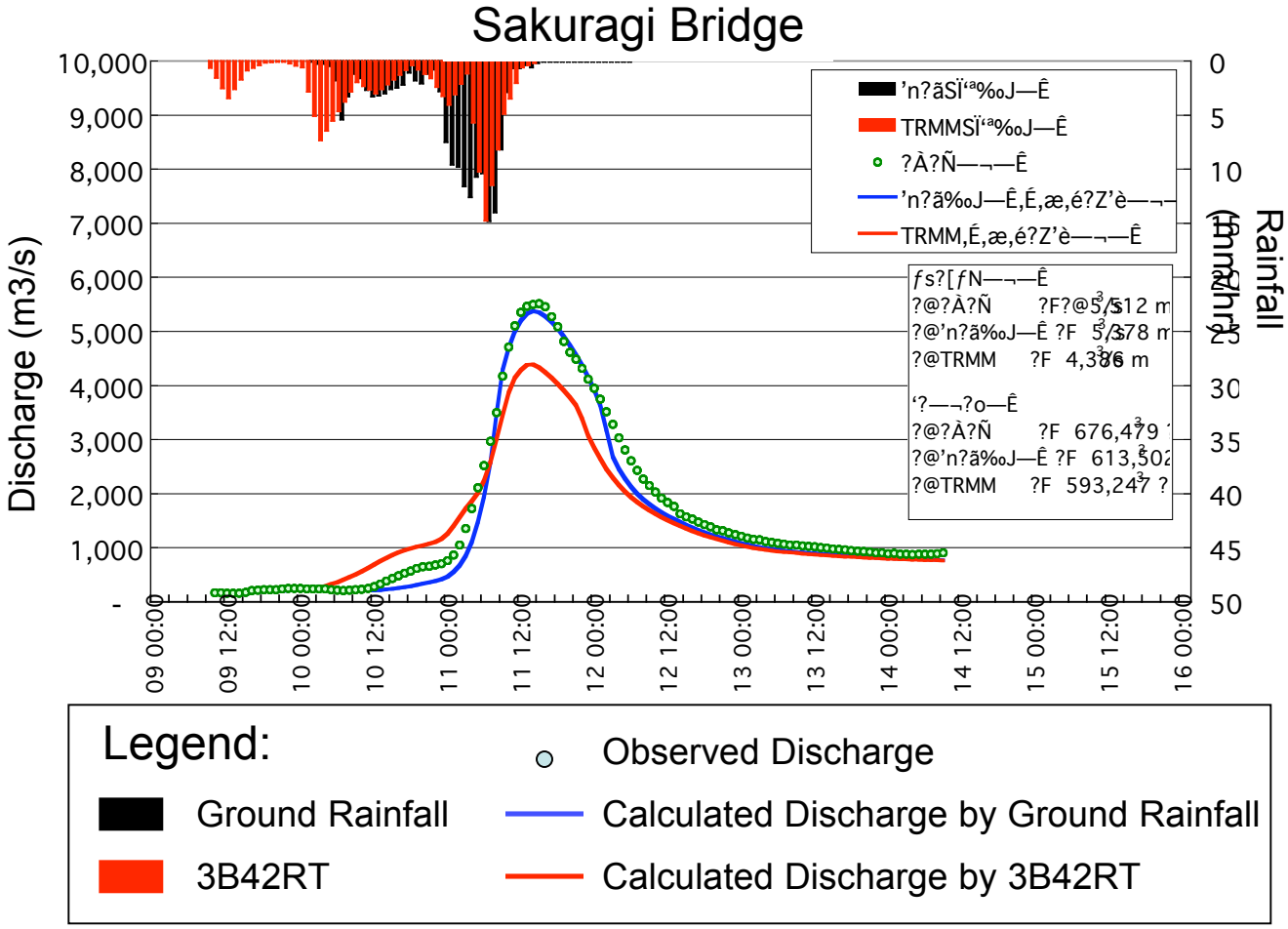
Result

- At the beginning of rain, 3B42RT overestimates against ground observation data.
- 3B42RT underestimates against observed peak rainfall.
- It is confirmed that when the accumulative time becomes longer, the relative error becomes lower. (24 hours: 40 %, 48 hours: 20 %, Total Rainfall (72 hours): 10 %, 3B42RT underestimates.)

Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

Comparison by Discharge





Legend:

- Ground Rainfall
- 3B42RT
- Observed Discharge
- Calculated Discharge by Ground Rainfall
- Calculated Discharge by 3B42RT

Results

■Peak discharge calculated by 3B42RT underestimates against observed discharge by 10 – 25 %. The reason is that rainfall of 3B42RT underestimates against observed rainfall data.

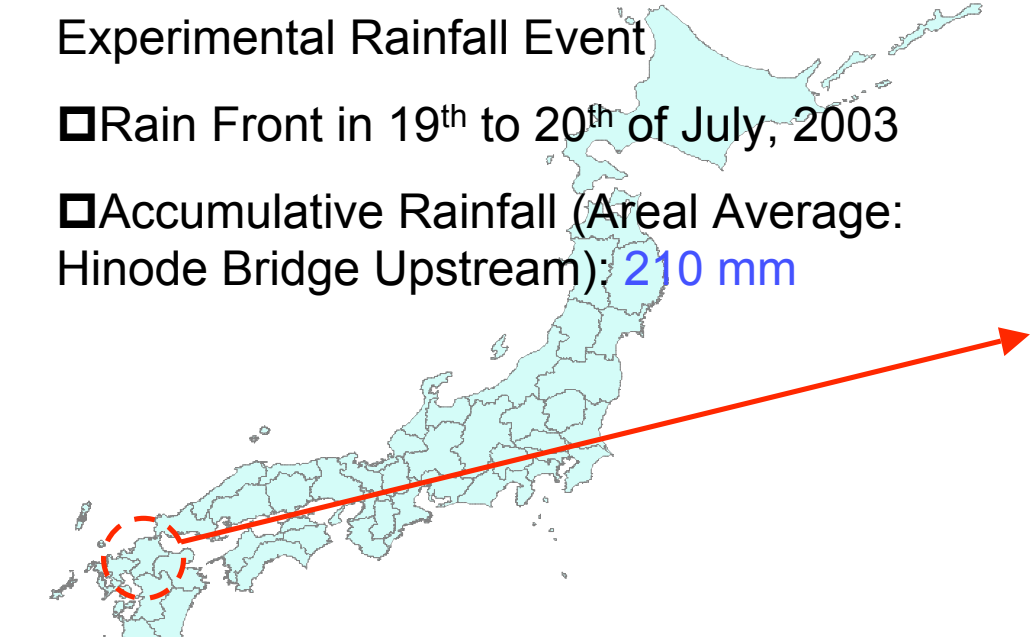
■Calculated time when peak discharge occurs doesn't have big difference with observed time.

Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

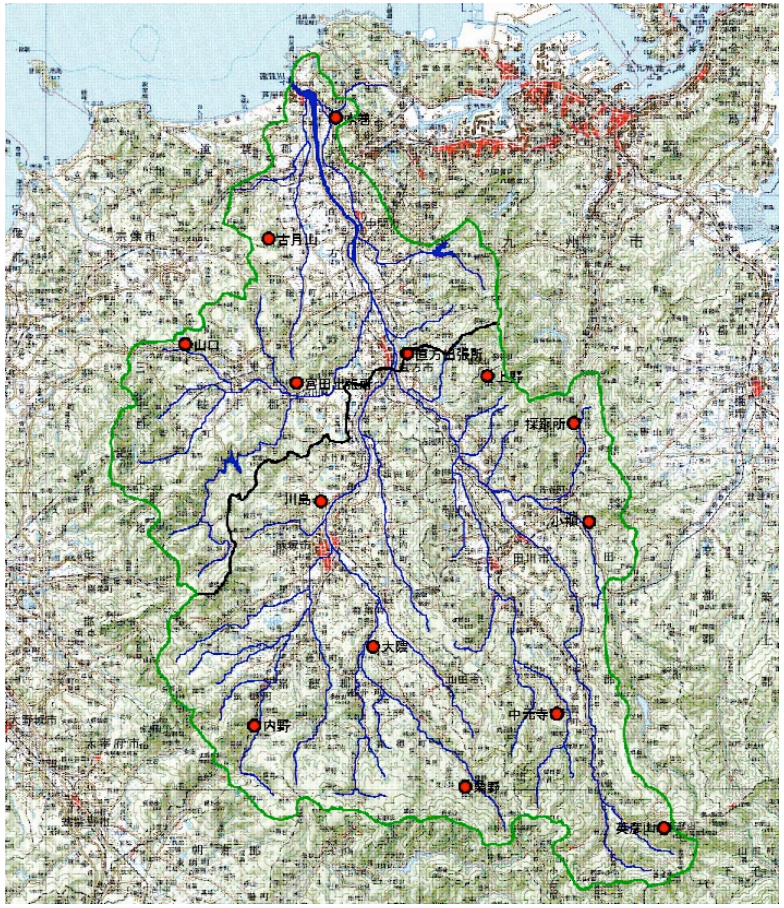
Onga River Basin

Experimental Rainfall Event

- Rain Front in 19th to 20th of July, 2003
- Accumulative Rainfall (Areal Average: Hinode Bridge Upstream): 210 mm



Onga River Basin (Kyusyuu Region)



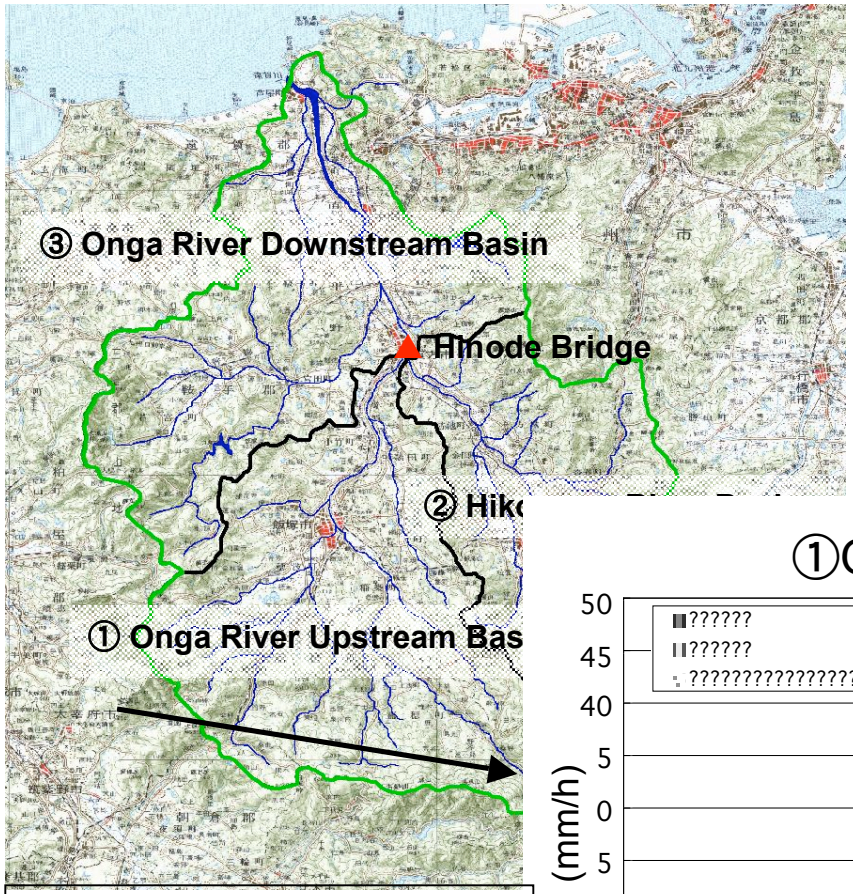
Area: 1,026 km^2

Rainfall Stations: 14 stations

(73.3 km^2/station)

Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

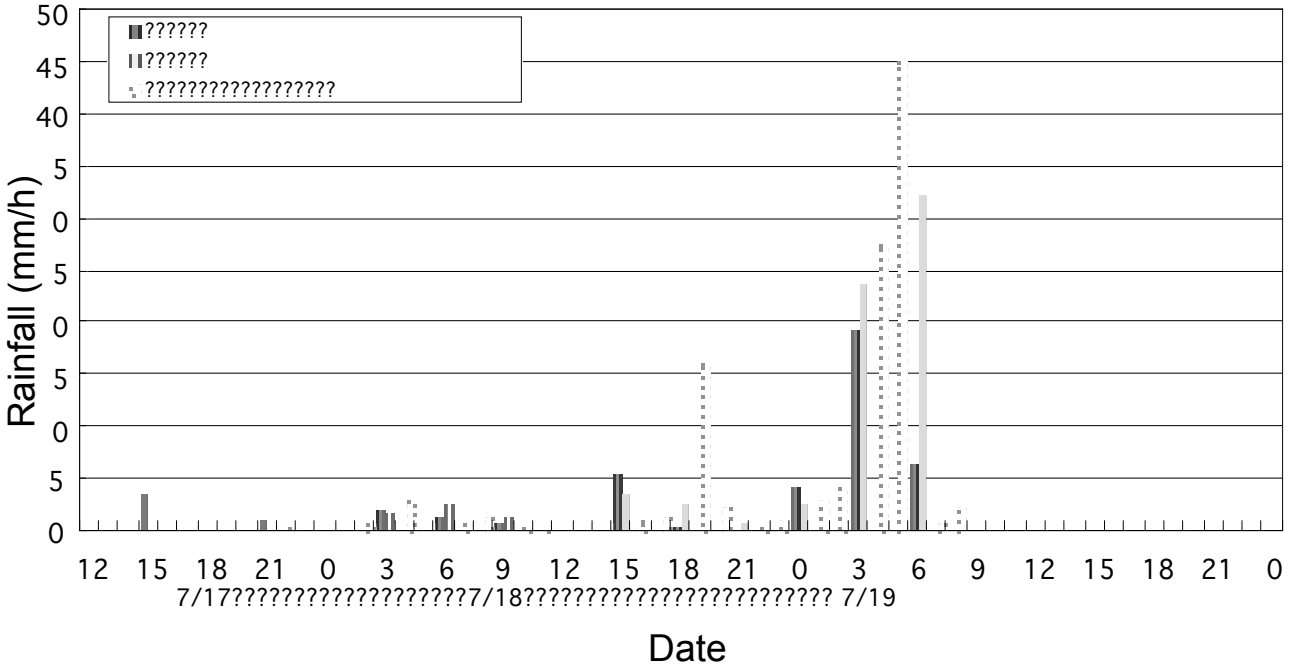
Comparison by Rainfall



Legend

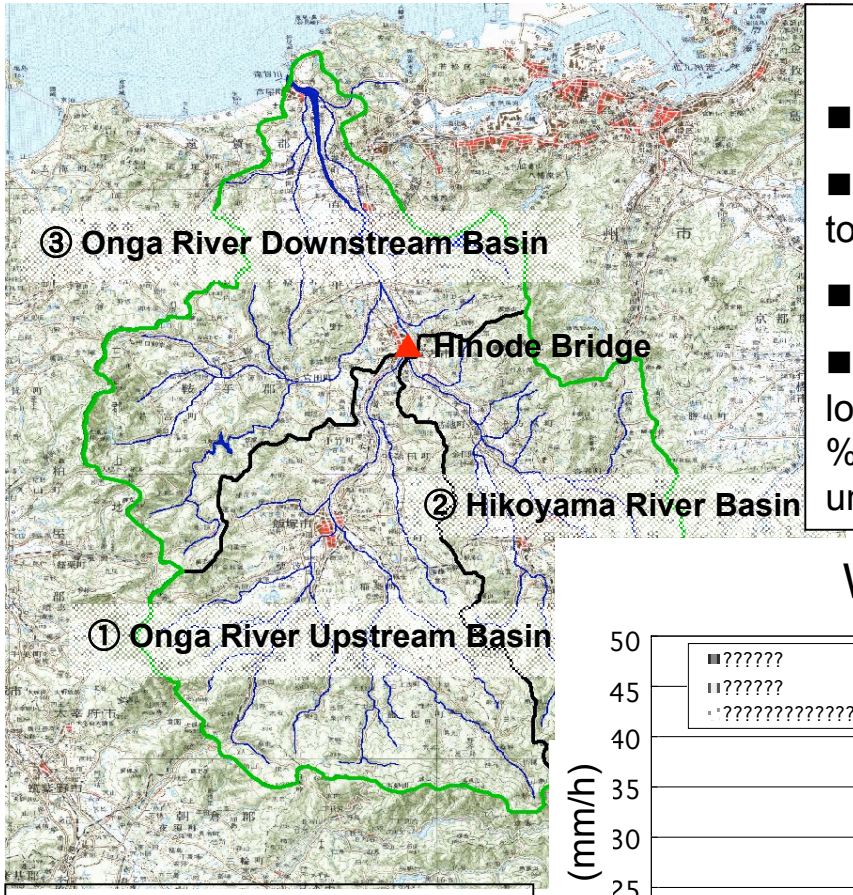
- 3B42RT
- Ground Observation
- Ground Observation data when 3B42RT is not available

①Onga River Upstream Basin (366 km²)



Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

Comparison by Rainfall



Results

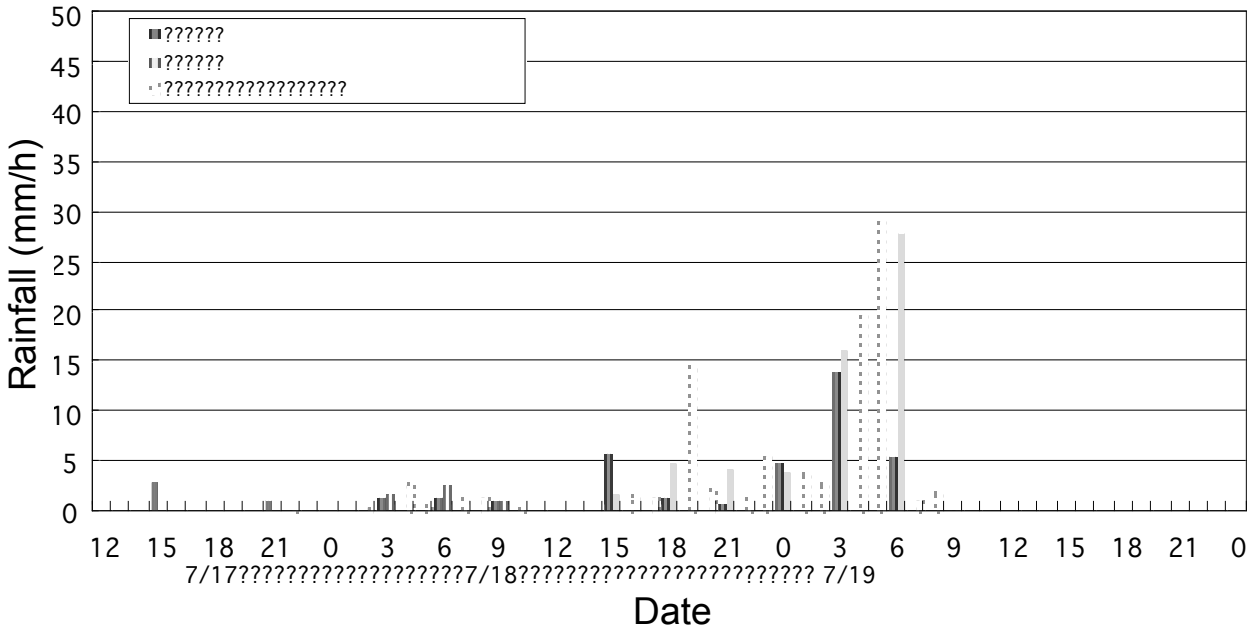
■3B42RT doesn't seem to observe peak rainfall accurately.

■3B42RT underestimates against ground observation data totally.

■3B42RT misses the strong rain.

■It is confirmed that when the accumulative time becomes longer, the relative error becomes lower. (24 hours: about 40 %, Total Rainfall (72 hours): about 30 %, 3B42RT underestimates.)

Whole Onga River Basin(1,026 km^2)

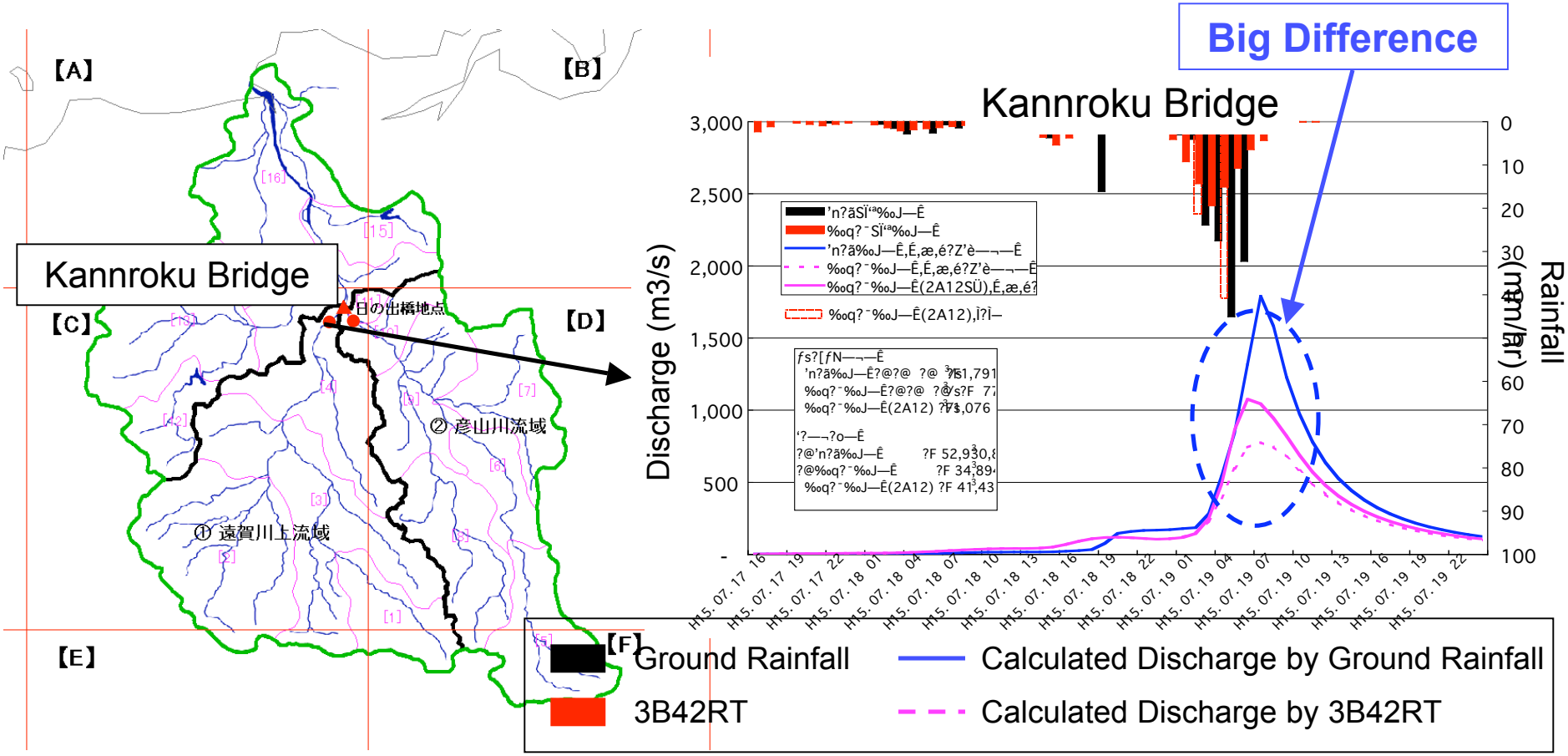


Legend

- 3B42RT
- Ground Observation
- Ground Observation data when 3B42RT is not available

Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

Comparison by Discharge



Results

■There is the big difference between calculated discharge by ground observed rainfall and 3B42RT.

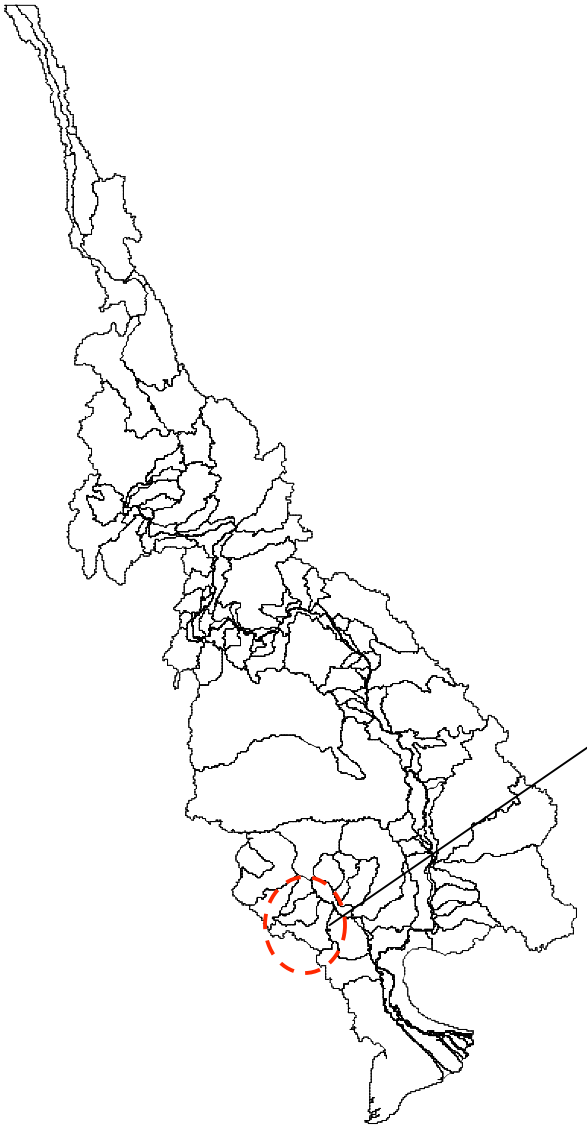
■Because peak rainfall of 3B42RT underestimates against ground observation data, the calculated discharge by 3B42RT also underestimates.

■It is very difficult in this basin to apply 3B42RT for flood forecasting and other uses without any support by ground observation data.

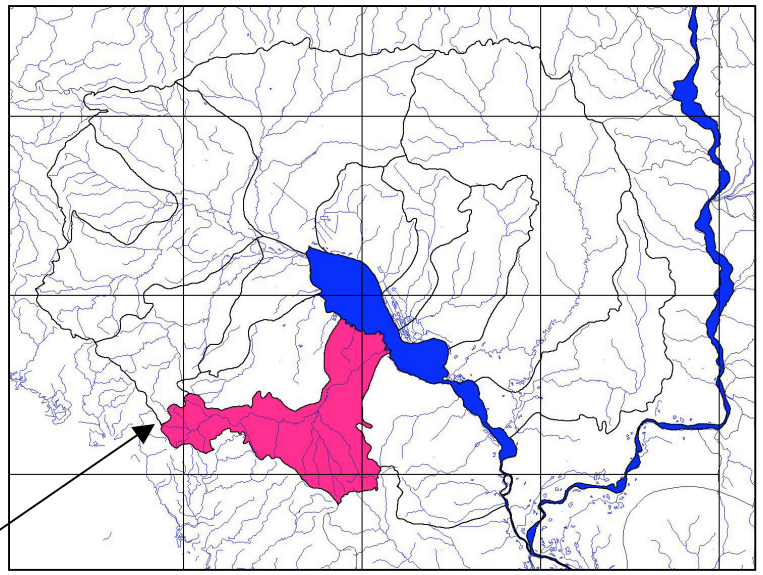
Material is provided by Ministry of Land Infrastructure and Transport (MLIT) and International Development Institute (IDI)

Pursat River Basin

Pursat River Basin (in Cambodia)



Mekong River Basin



- South West of the Tonle Sap Lake
- The area is 6,013 km^2.
- The hydrological data is very poor.
- Flood disasters happen often.
- It is important to understand the runoff volume from Pursat River to Tonle Sap Lake because the water balance of Tonle Sap Lake depends on the runoff from surrounding basins.

Runoff Simulation in 2002 and 2005 with 3B42RT

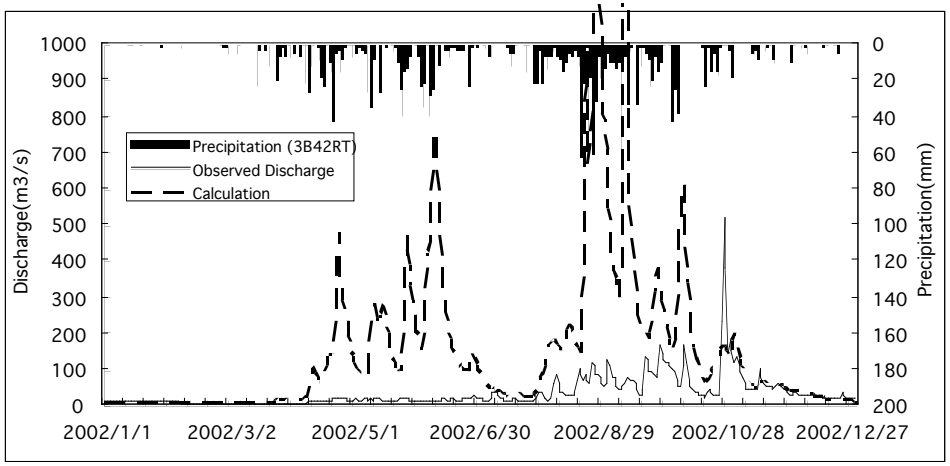
Condition of Simulation

- Period: 2002 and 2005
- Area: 6,013 km^2
- Time Step: 1 day
- Check Point of Discharge: Bactrakoun
- Rainfall Data: **3B42RT**
- Meteorological Data: Observed Meteorogical Data at Chhnok Tru station
- DEM: USGS GTOPO30

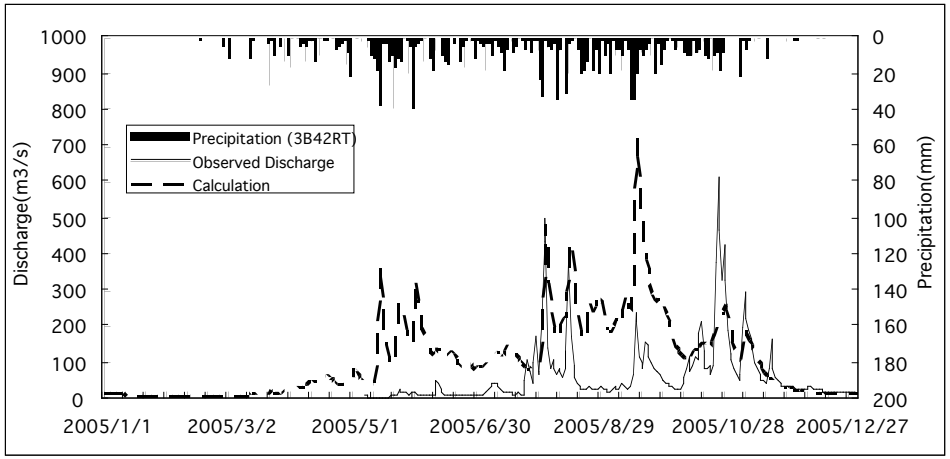
Specific comparison between ground rainfall data and 3B42RT is not examined in this basin. Ground rainfall data is only available at 5 stations near the Pursat River Basin. 3 of them are outside of the basin. It means that the areal average rainfall data based on the ground rainfall data is not so reliable. The most reliable data is discharge in this basin.

The location of Rainfall Stations and Chhnok Tru Meteorological Stataion

Runoff Simulation in 2002 and 2005 with 3B42RT



Simulation result in 2002

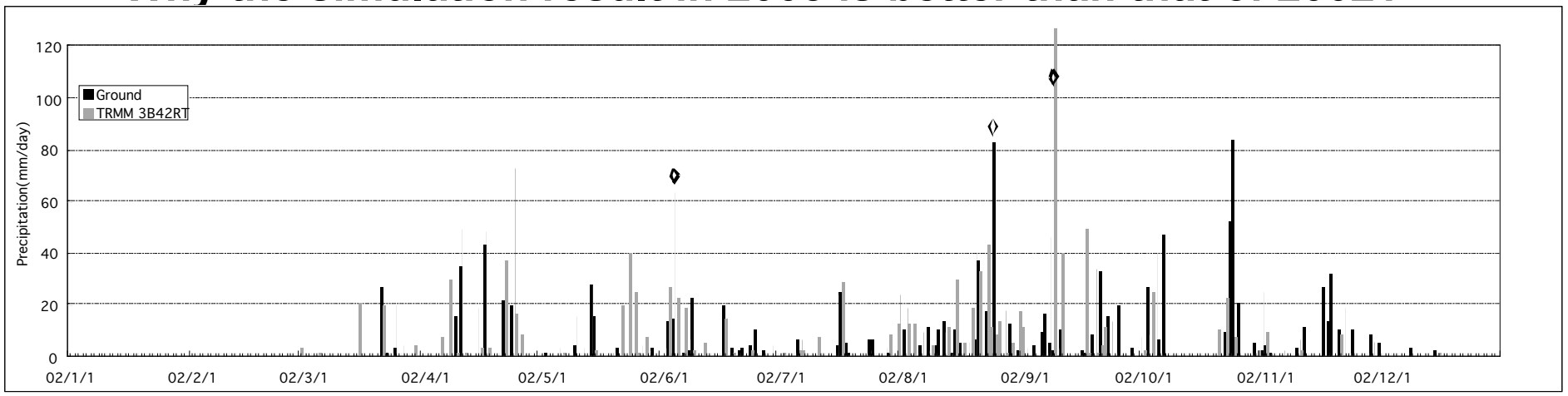


Simulation result in 2005

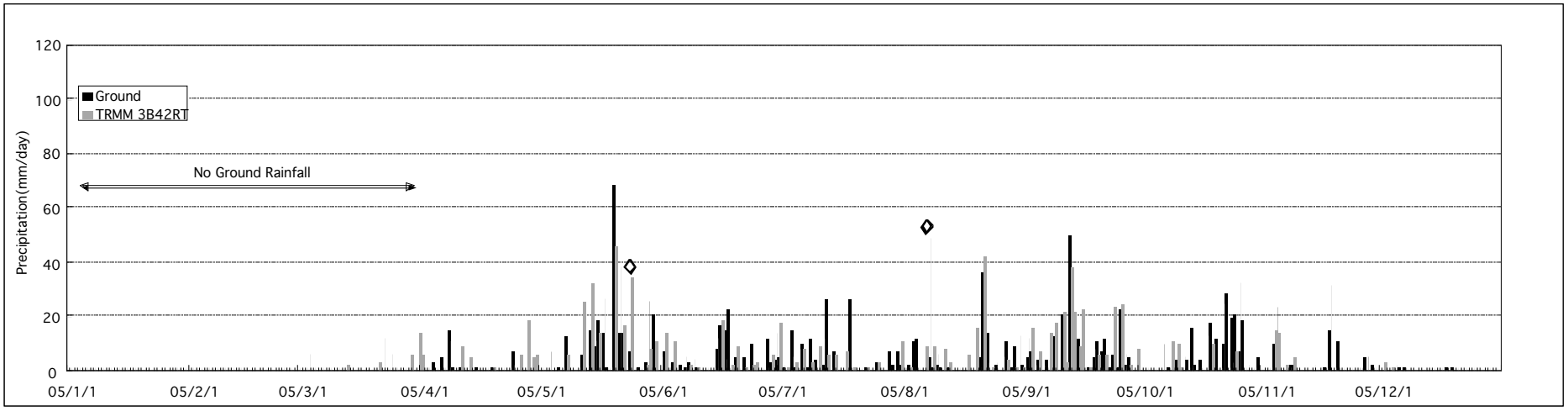
_		2002	2005
Average Rainfall over Watershed (mm) (3B42RT)		2,110	1,500
Ground Rainfall Data (5 Stations)		1,344	1,326
Total Runoff (Observed m3)		1,022,334,608	1,239,828,530
Total Runoff (Calculated m3)		4,870,597,392	3,175,327,613
Total Runoff Volume Error		**-3.76**	**-1.56**
Runoff Depth (mm)	Observed	242	293
	Calculated	1,151	750
Evapotranspiration (mm)		780	668

Discussion

Why the simulation result in 2005 is better than that of 2002?



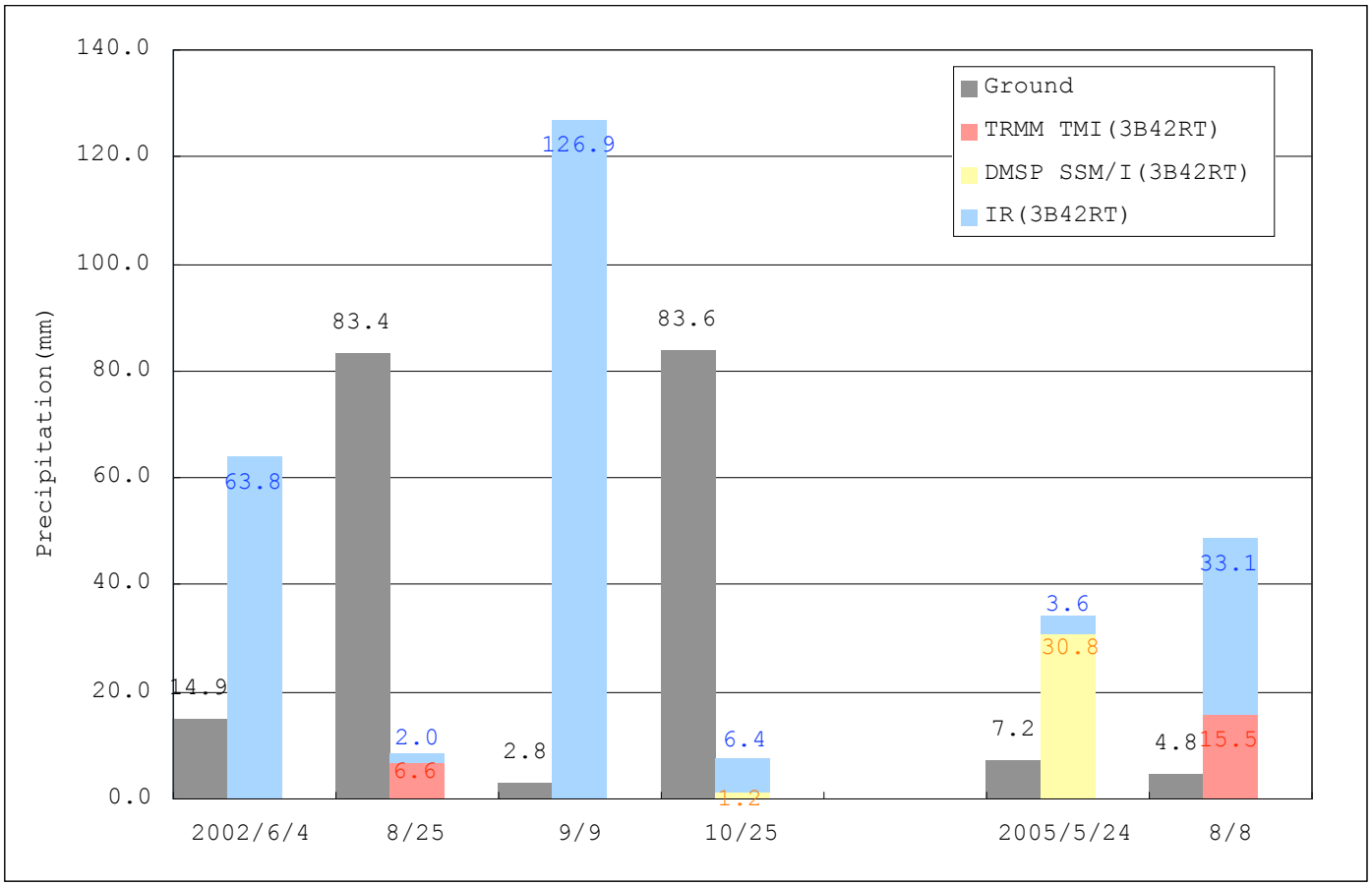
Comparison of 3B42RT with Ground Rainfall Data (2002)



Comparison of 3B42RT with Ground Rainfall Data (2005)

It is clear that there are so many rainfall events in which the difference between 3B42RT and ground rainfall data is very big. On the other hand, the number of such events decreased in 2005.

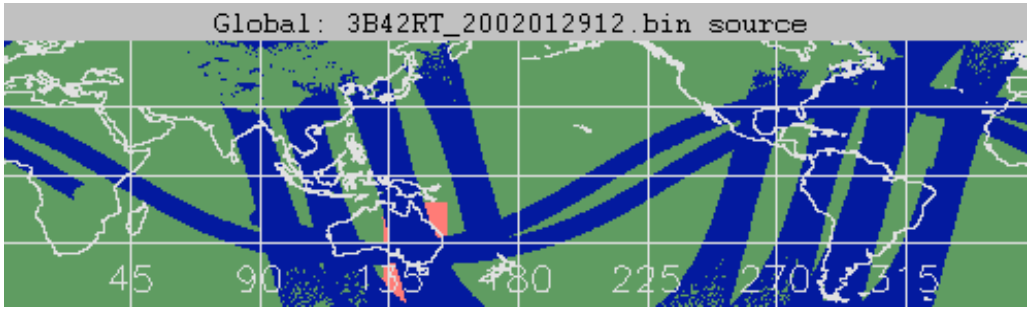
Discussion



Which sensor's data is applied in 3B42RT when error is big?

- When 3B42RT overestimates against ground rainfall very much, the main component is the data observed by IR and microwave sensors' data are not included.
- IR data is seemed to be the main reason of big errors.
- It means that if the number of microwave sensors increases, the accuracy of 3B42RT becomes better.

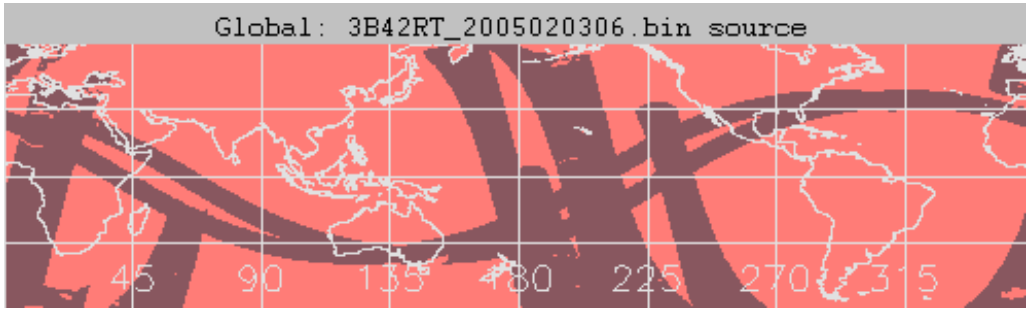
Discussion

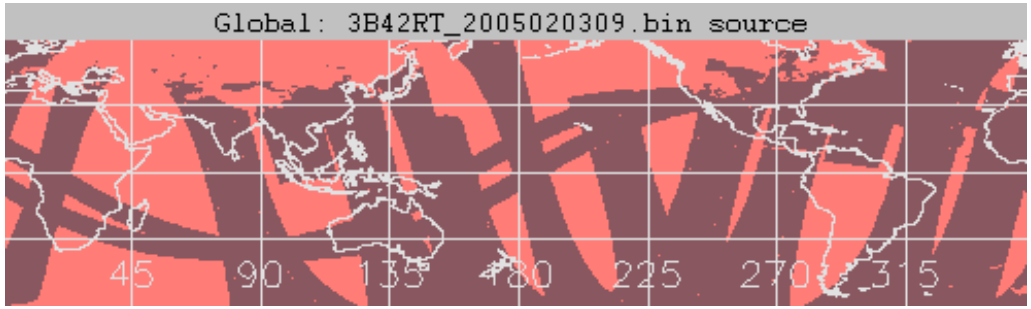


2002/01/29 12:00 (UT)

3B42RT
配信開始

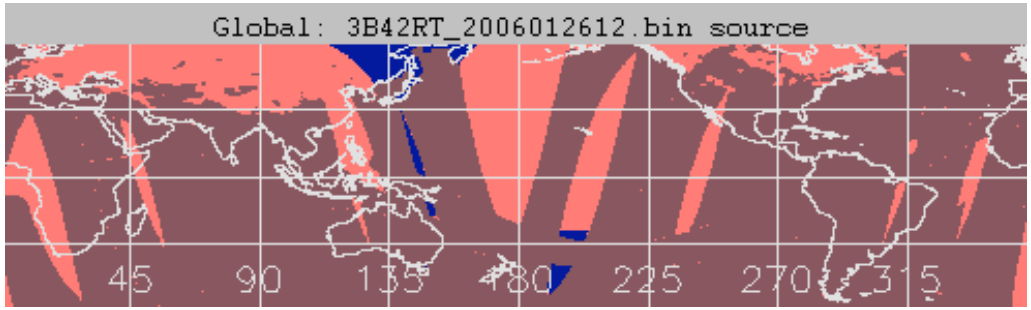
TRMM TMI
DMSP SSMI





2005/02/03 9:00 (UT)

+ AQUA AMSR-E
+ NOAA AMSU-B



2006/01/26 12:00 (UT)

The number of microwave sensors' data used in 3B42RT has increased from 2005.

The accuracy of 3B42RT becomes better.

Conclusion

- Usually, 3B42RT underestimates peak rainfall against ground observation rainfall data. It results that the estimated discharge based on 3B42RT is also smaller than observed discharge. (Experiments in Kitakami River Basin and Onga River Basin)

- Some corrections (ex. Online or offline calibration by ground rainfall…) are required to apply 3B42RT for hydrological use at present. There are still some challenges to apply.

- It is confirmed that the accuracy of 3B42RT becomes better because the number of microwave sensors used in 3B42RT has increased. (Experiment in Pursat River Basin)

- If Global Precipitation Measurement (GPM) plan is achieved, the accuracy of 3B42RT will become much better.